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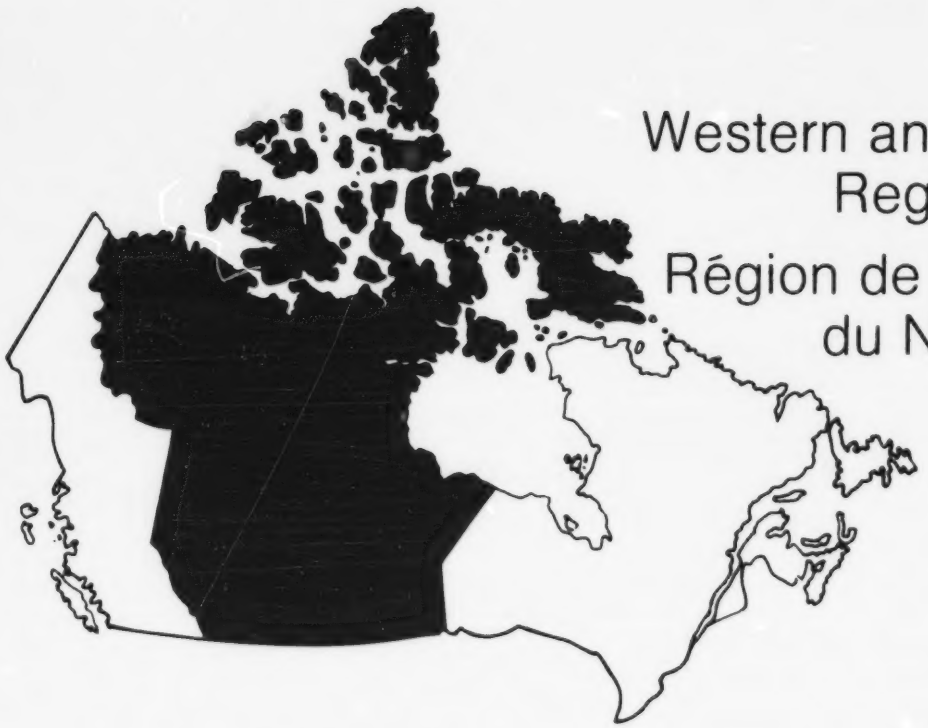

# Western and Northern Region

# Région de l'Ouest et du Nord

Environmental Protection Service

Service de la protection de l'environnement

April 16, 1987

# WATER QUALITY STUDY FOR THE WASAGAMING REGION OF RIDING MOUNTAIN NATIONAL PARK

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CP(EP)WNR87/88-10

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## ABSTRACT

Octopus Lake, located south of the Town of Wasagaming, immediately outside Riding Mountain National Park, is euthrophic and subject to the inflow of runoff from agricultural land and a populated area that has the potential for further and significant development; it flows into Ominnik Marsh.

Ominnik Marsh, South Lake and Clear Lake, within Riding Mountain National Park, are subject to the inflow of waters enriched with nutrients and organics from adjacent lakes and the Wasagaming lagoon system, and also from agricultural run-off and run-off from populated areas. Surface run-off from agricultural activities is considered the principal source of the nutrients in South Lake. Clear Lake is not observably affected by nutrients.

The Wasagaming lagoon system provided effective wastewater treatment during the summer sampling period. It is probable however that seepage from the Wasagaming lagoon system enters Omminik Marsh on an ongoing basis and raises nutrient levels in an area of the marsh immediately adjacent to the lagoon cells. The lagoon system was organically overloaded by the late summer but it is believed there was significant recovery during the fall. The recommended time to discharge effluent from this lagoon system is during the late spring.

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## 1.0 Introduction

Riding Mountain National Park is a Parks Canada facility in Manitoba. The Town of Wasagaming is located within the southern boundary of the Park, and is a popular recreation area used intensively during the summer.

In a February, 1982 meeting, Parks Canada representatives expressed their concern to Environmental Protection staff about "uncharacteristic" odours sometimes emanating from Ominnik Marsh in the approximate areas where discharges from Octopus Lake enter the marsh, and also near the Wasagaming lagoon system. Environmental Protection agreed to undertake a study to obtain some basic water quality data in order to: determine if current problems existed; identify where problems may arise in the future; and recommend how Parks Canada could maximize lagoon performance.

The objectives of the study were:

1. To determine the impact and the potential for impact, of run-off waters entering Octopus Lake, Ominnik Marsh, South Lake and Clear Lake.

2. To determine the impact and the potential for impact, of effluent discharges and possible seepage from the Wasagaming lagoon system upon Ominnik Marsh.

3. To determine the possible cause of anaerobic conditions in Ominnik Marsh that may develop from time to time.

4. To establish background water quality data for Octopus Lake, Ominnik Marsh, South Lake and Clear Lake.

5. To determine the treatment performance of the three-celled, Wasagaming lagoon system during the summer when maximum hydraulic and organic loadings occur.

6. To review operational procedures for the Wasagaming lagoon system and make recommendations for operation, maintenance and upgrading requirements, including monitoring and discharging effluent.

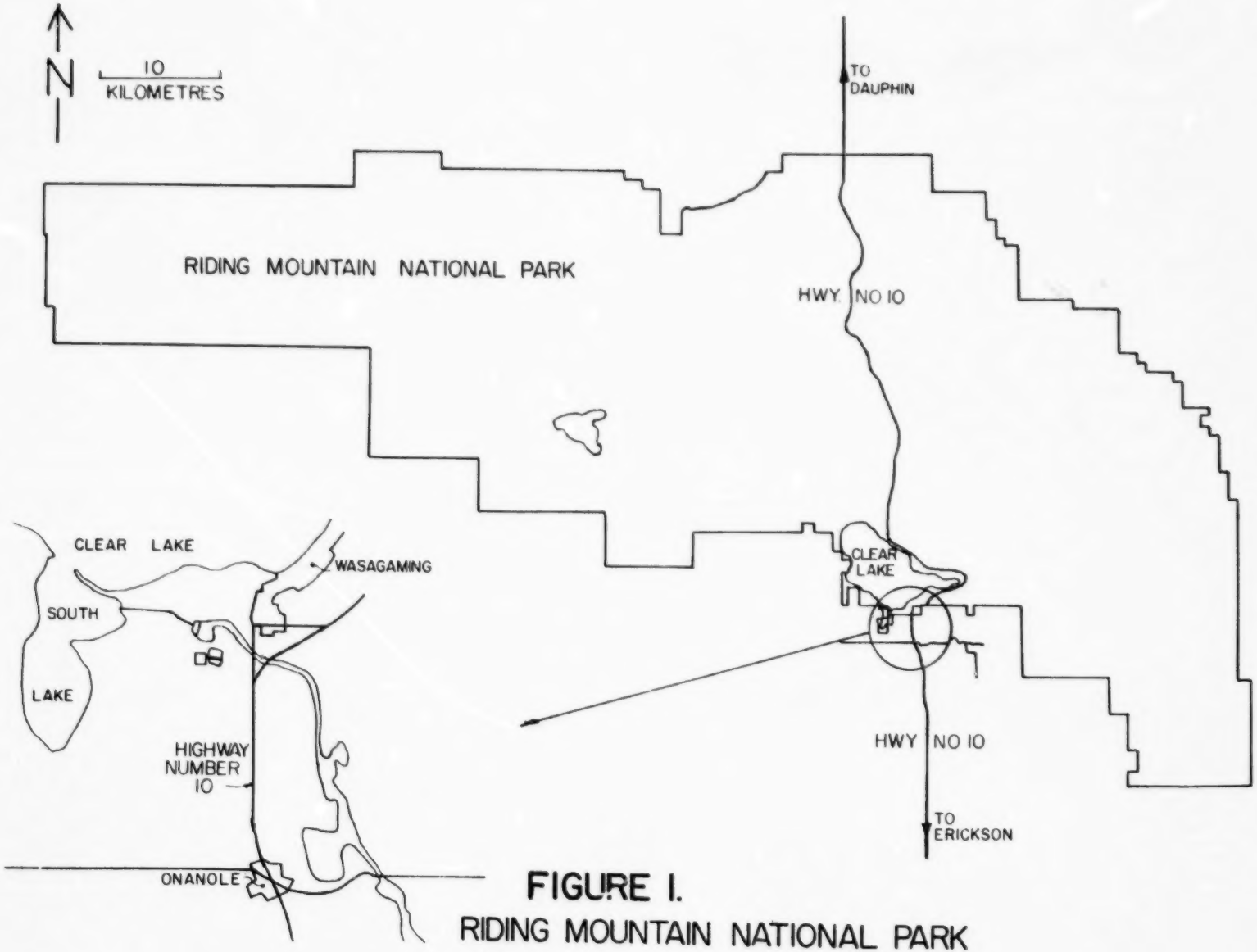
## 2.0 Study Area

### 2.1 Wasagaming and Adjacent Area Development

Riding Mountain National Park in Manitoba is a popular vacation area located in western Manitoba (Figure 1). The town of Wasagaming is located within the southern boundary of the park (Figures 1 & 2). For the summer months (June, July, August) the number of people in the Wasagaming-Clear Lake area may fluctuate between 5,000 and 10,000 on any given day. On occasion, it has been estimated the population has reached 15,000. During the winter months the approximate number of Parks Canada staff and their families living in Wasagaming is 45.

There are 246 cottages in the Wasagaming-Clear Lake area and 39 commercial establishments. These are opened in the late spring and must be closed during the early fall. All businesses and cottages in Wasagaming connect with the community water supply system. They discharge wastewater to the community sewers which drain to the Wasagaming lagoon system (Figure 2).

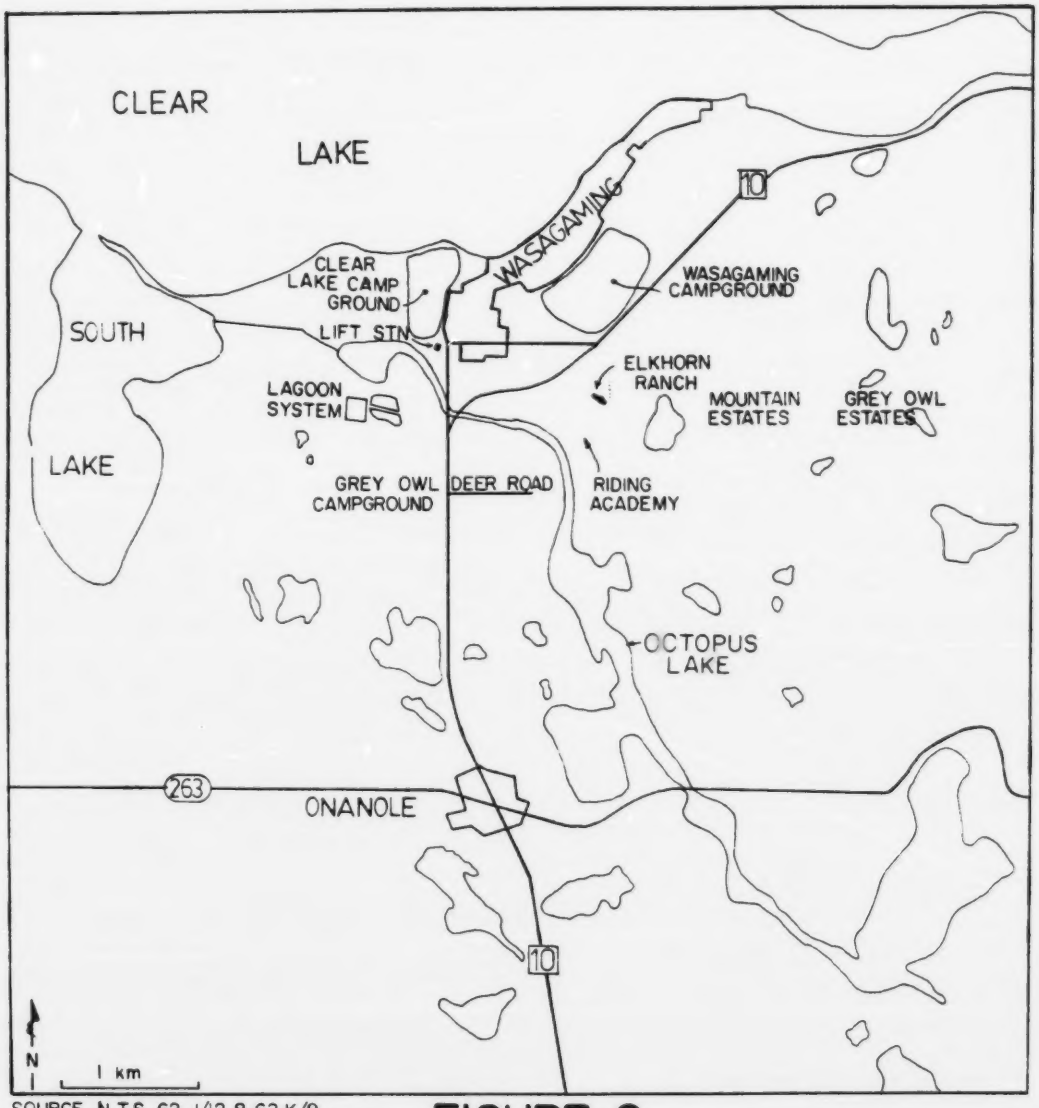
The Wasagaming campground, which opens for the long weekend in May and closes following the Labour Day weekend, can accommodate in excess of 500 people. The Clear Lake




# FIGURE 1.

## RIDING MOUNTAIN NATIONAL PARK

the Wasagaming study area is located on the southern boundary of the park south of Clear Lake

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# FIGURE 2.

## WASAGAMING STUDY AREA - TOWNSITE AND ADJACENT LOCATIONS

Wasagaming and locations in the study area along the southern boundary of Riding Mountain National Park.

Campground, located west of the Wasagaming business area, is a seasonal campground comprised primarily of trailers which are occupied from May until September. The population of this campground peaks at approximately 525 towards the end of July and the first week of August. Wastewater from trailers and public washrooms is discharged from both campgrounds to the Wasagaming lagoons.

The area outside the park immediately south of Wasagaming is the Local Government District of Park. The drainage from the area south of Wasagaming flows into the Clear Lake drainage system. Numerous private developments are located south of the park. These include: the Elkhorn Ranch Resort complex, a riding academy; a group of approximately 75 residences along Deer Road; a group of smaller commercial establishments and residences which includes a trailer park, a ball park and a drive-in theatre directly south of the Deer Road area development; the Village of Onanole, approximately two kilometres south of RMNP (population 200); three private development areas southeast of the park called Mountain Estates, Grey Owl Estates and Parkview Estates; and Grey Owl Campground just west of Provincial Highway Number 10 (Figure 2).

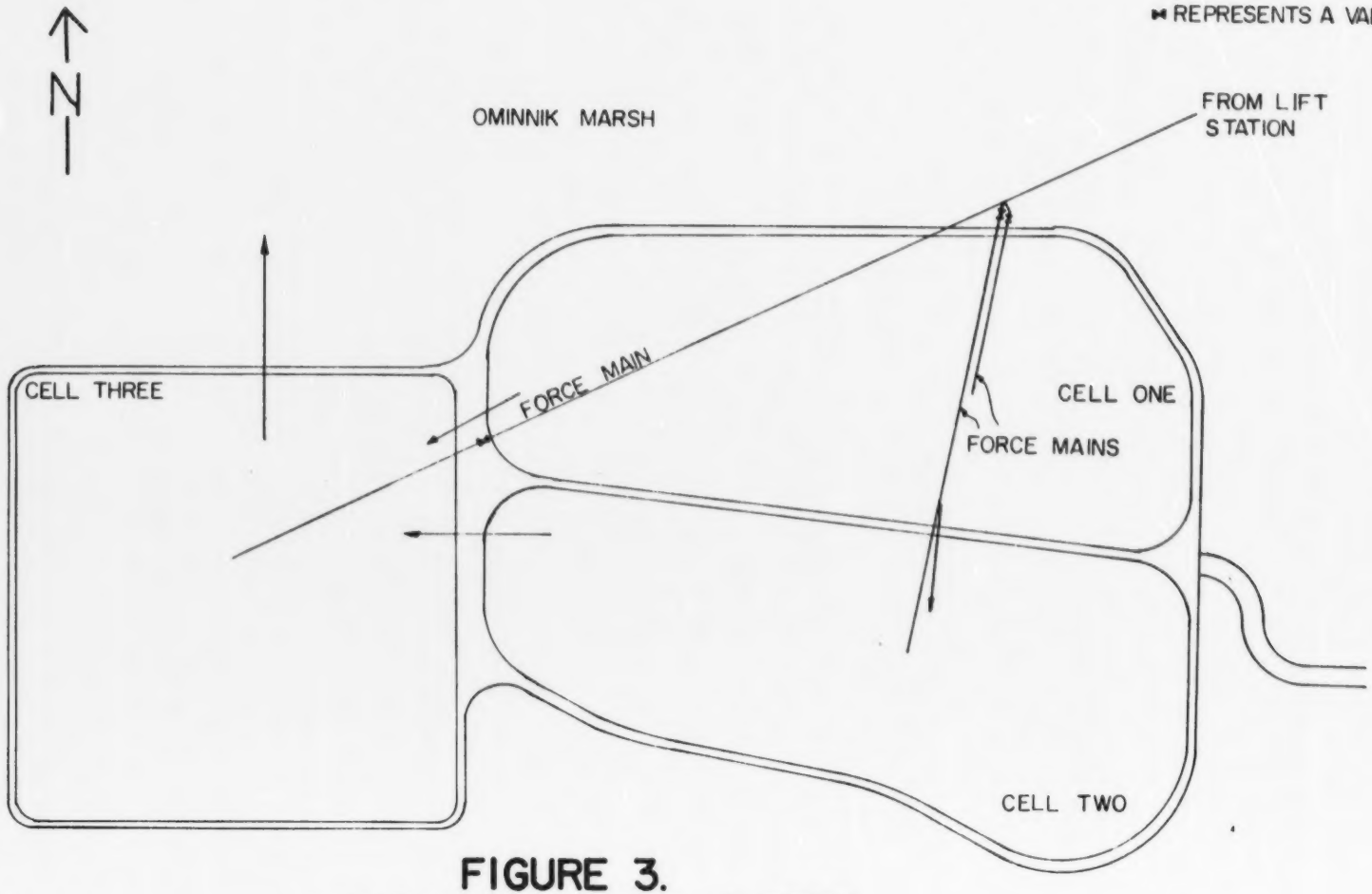
Parks Canada is considering the construction of a marina on Clear Lake, immediately west of the Clear Lake Campground

(Figure 2). The plans include accommodation for 300 - 350 pleasure boats, and fueling facilities. The proposed marina may have a sewage pumpout facility. These wastewaters would presumably be pumped to the Wasagaming lagoon system.

There are six church camps, located along the southwest corner of Clear Lake, which are normally used during the summer. These camps have an estimated total capacity for approximately 400 people. All church camps have their own septic tanks and tile field systems.

## 2.2 The Wasagaming Lagoon System

The Town of Wasagaming is served by a three-celled lagoon system (Figure 3). The lagoons are located in a marshy area which slopes northward to Ominnik Marsh and westward toward South Lake (Figure 2). The subsurface of the lagoon area consists of fine-to-medium sand and gravelly-to-clay tills which occur at various depths (1).




# FIGURE 3.
## WASAGAMING LAGOON SYSTEM

Wastewater from the main Wasagaming lift station is pumped to cell one. Effluent from cell three can be discharged to Ominnik Marsh. Arrows indicate the typical flow of wastewater in the system.

## 3.0 Methods

### 3.1 Sample Collection and Analysis

Water and wastewater samples were collected on three occasions during the summer of 1982. Raw sewage samples were collected as 24-hour composite samples on June 23/24, July 26/27, and August 17/18. All other samples were grab samples taken on each sampling occasion: June 24, July 27 and August 18.

Sample collection, shipment and analysis for pH, specific conductance (conductivity), residues, alkalinity, biochemical oxygen demand, total organic carbon, total inorganic carbon, ammonia nitrogen, organic nitrogen, nitrate-nitrogen, and total phosphorus were carried out in accordance with the methods established by Analytical Methods (2), published by the Technical Services Laboratory of the Province of Manitoba. These procedures are consistent with those described in the fifteenth edition of Standard Methods for the Examination of Water and Wastewater (3), (commonly referred to as "Standard Methods"). Lab analyses were conducted at the W.M. Ward Technical Services Laboraltory, of the Province of Manitoba.

Bacteriological samples were collected, shipped and analyzed in accordance with the procedures outlined in

Standard Methods (3). Analyses were conducted at the Cadham Provincial Laboratory, of the Province of Manitoba. Results were reported as "most probable numbers" (MPN) for total coliform and fecal coliform bacteria.

Dissolved oxygen levels were determined in the field using the Winkler or iodometric method, described in Standard Methods (3).

## 3.2 Sampling Sites - Clear Lake Drainage System

Grab samples were collected from the Octopus Lake-Ominnik Marsh-South Lake drainage system into Clear Lake, on three occasions during the summer of 1982. The purpose was to develop comparative water quality data for the sampling sites, for several common parameters. Sampling depth for all grab samples was to a depth of approximately 20 cm.

Nine sampling stations were identified in Octopus Lake, Ominnik Marsh, South Lake and Clear Lake (Figures 4 & 5). The sites are as follows:

Site 1. Upper Octopus Lake
Samples were taken from the east shoreline of the lake, approximately 200 metres north of the location where Provincial Road No. 263 crosses the lake.

Site 2. Lower Octopus Lake at Deer Road
This site is located north of Site 1, on the west shore of the lake opposite Deer Road.

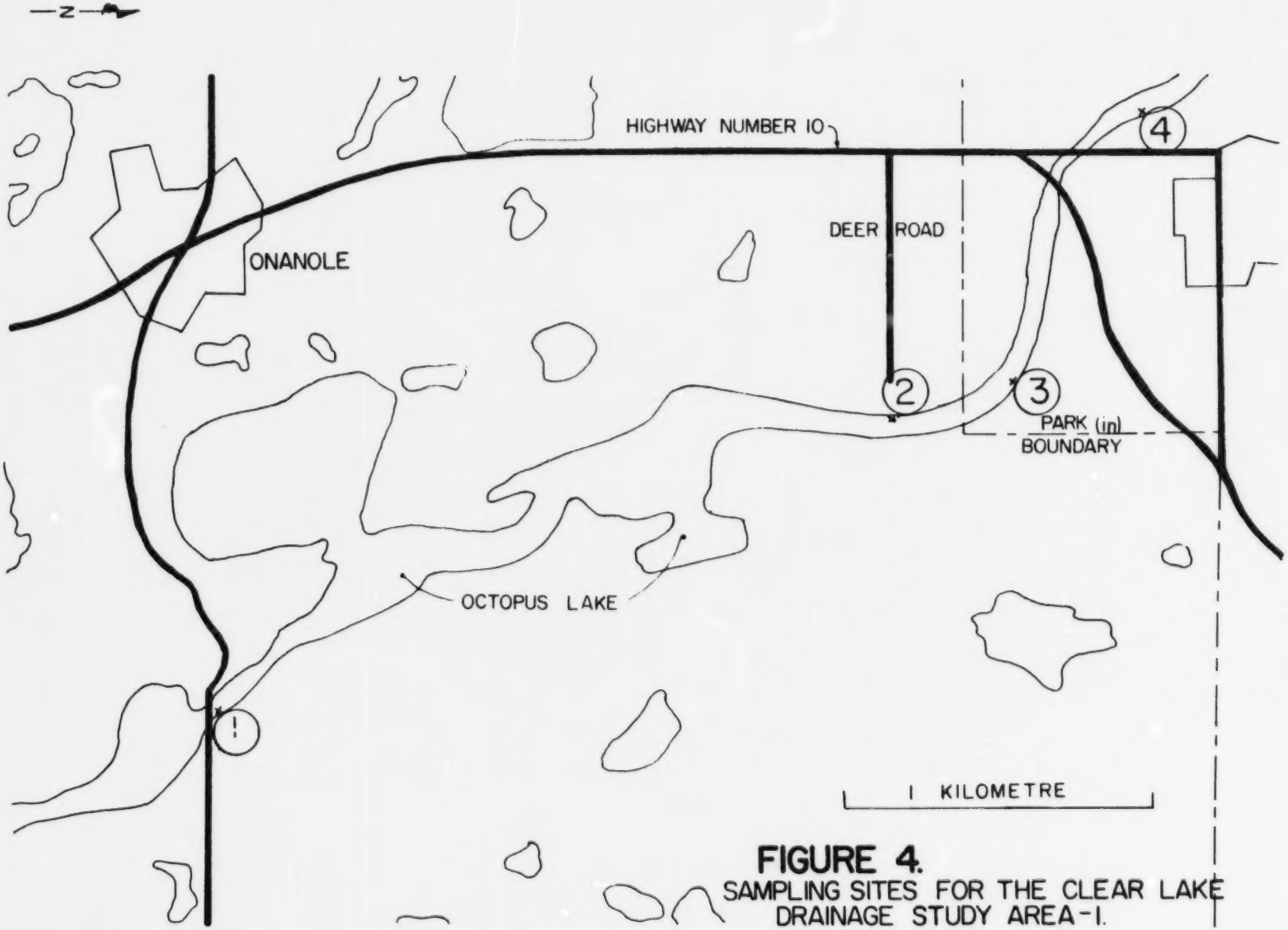



**FIGURE 4.**
SAMPLING SITES FOR THE CLEAR LAKE DRAINAGE STUDY AREA-1.

Water bodies and sampling sites in the southeastern part of the study area.

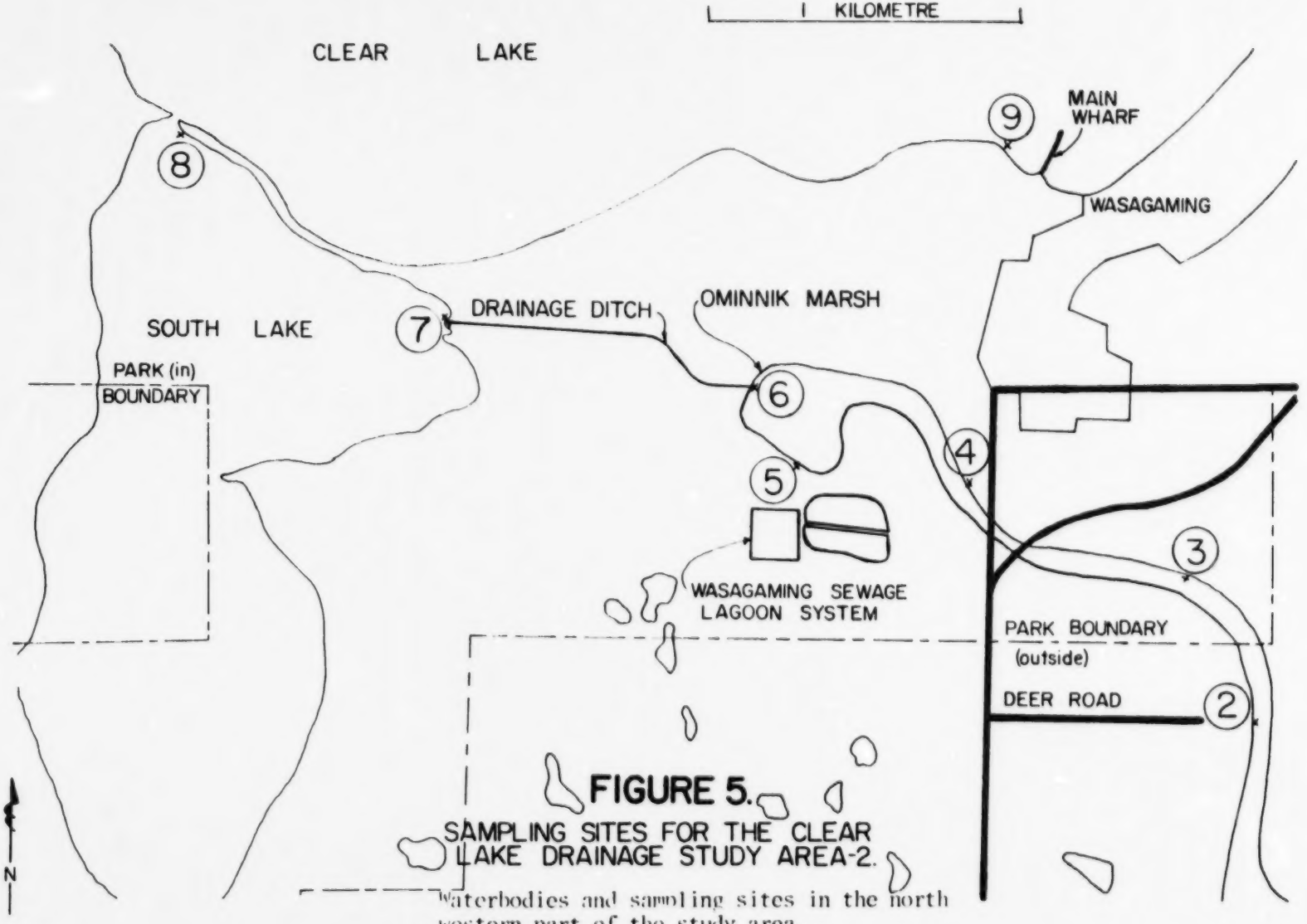



**FIGURE 5.**
SAMPLING SITES FOR THE CLEAR LAKE DRAINAGE STUDY AREA-2.

Waterbodies and sampling sites in the north western part of the study area.

Site 3. Lower Octopus Lake at Riding Academy

This site is located at the north end of Octopus Lake about 200 metres east of the outflow culverts beneath Provincial Highway No. 10.

Site 4. Ominnik Marsh Inlet

This site is located at the inlet to Ominnik Marsh approximately 50 metres west of the culvert beneath Provincial Highway No. 10, and along the north shore of the inlet area.

Site 5. Ominnik Marsh - Adjacent to Wasagaming Lagoons

This area is located at the southwest corner of the marsh adjacent to the discharge point of the Wasagaming lagoon system from cell three. Grab samples were taken by walking into the marsh, opposite the cell three overflow pad, to a point where the water was approximately two feet deep. Access is from the lagoon property.

Site 6. Ominnik Marsh Drainage Ditch Inlet

This ditch was constructed to drain Ominnik Marsh to South Lake. Samples were taken at a point approximately 10 metres within the ditch inlet, from the north bank of the ditch.

Site 7. Ominnik Marsh Drainage Ditch Outfall

This site within the ditch is approximately 30 metres from the ditch outfall to South Lake. Samples were taken from the north bank of the ditch.

Site 8. South Lake

This site is located at the northwest corner of South Lake near the point where a narrow shallow channel connects with Clear Lake. Samples were taken along the north shore of South Lake approximately 100 metres east of the connecting channel.

Site 9. Clear Lake

The sampling point is located along the south shore of Clear Lake in Wasagaming, approximately 100 metres west of the main wharf (breakwater).

## 3.3 Sampling Sites - Wasagaming Lagoon System

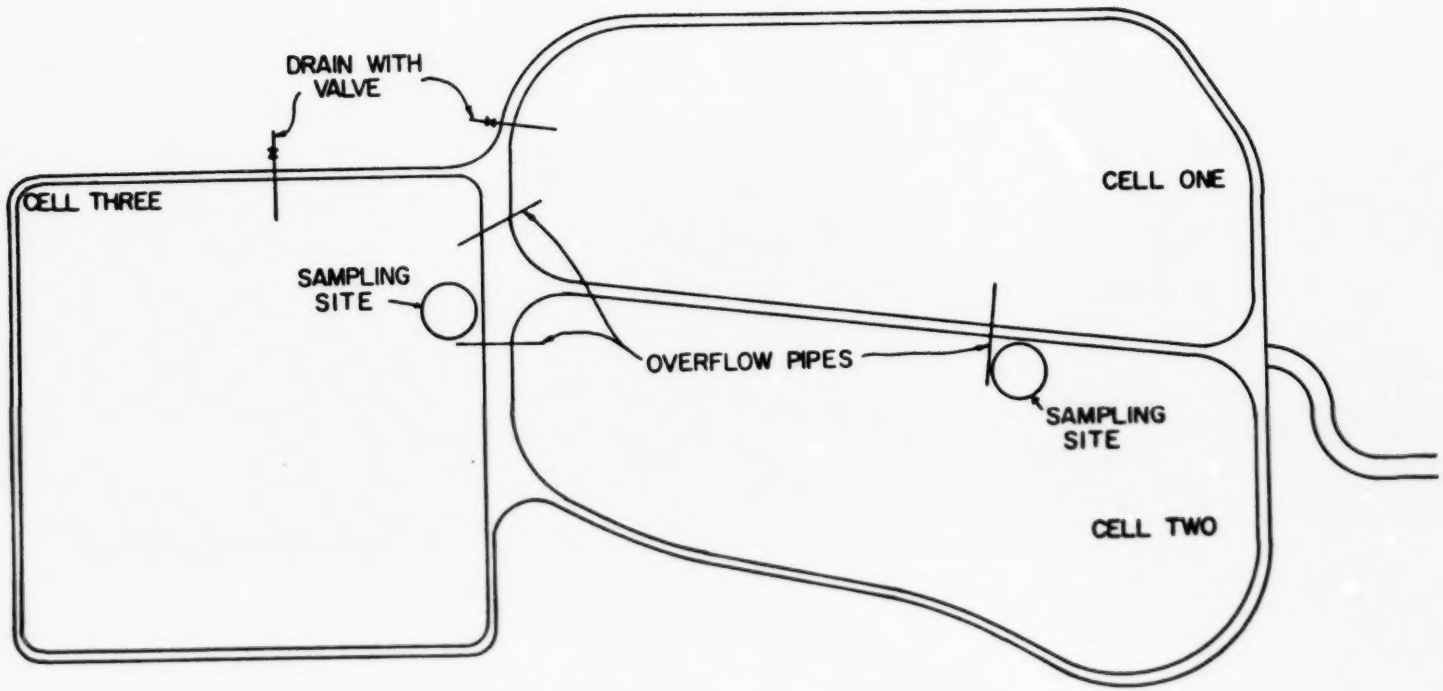
A second group of samples was taken from the Wasagaming

lagoon system (Figure 6) to determine the wastewater quality at various stages of treatment, and also to determine treatment performance of this system. Three sampling locations were used; the first was the sewage lift station (Figure 2), and the second and third were located at lagoon cells two and three respectively (Figure 6). The stations are as follows:

Main Sewage Lift Station - Raw Sewage
24-hour composite samples were taken at the main sewage lift station, at Wasagaming.

Lagoon Cell Two
Grab samples were taken to approximately 20 cm. beneath the surface from cell two beside the midpoint of the berm between cells one and two.

Lagoon Cell Three
Grab samples were taken to approximately 20 cm. beneath the surface from cell three adjacent to the inlet from cell two.




## FIGURE 6.
## SAMPLING SITES FOR THE WASAGAMING LAGOON SYSTEM.

Samples of raw sewage were taken at the main lift station. Lagoon samples were taken at points adjacent to the inlets to cells two and three.

## 4.0 Results and Discussion

### 4.1 Water Quality of Octopus Lake, Ominnik Marsh, South Lake and Clear Lake

#### 4.1.1 Upper Octopus Lake (Site 1)

Upper Octopus Lake is shallow and during the sampling period it was characterized by a substantial growth of aquatic plants. There was little algal growth and the waters were clear. The data collected for each parameter (Table 1) were not considered exceptional, and there was a tendency for them (eg. pH, conductivity, alkalinity, and residues) to be consistent throughout the sampling period. There was little evidence of impacts resulting from anthropogenic activities.

There was a slight tendency for the $BOD_5$ and Total Organic Carbon to increase during the summer, presumably as a result of decaying vegetation. This was also reflected by a decrease in the dissolved oxygen, during the summer, due partly to the increase in oxygen demand.

#### 4.1.2 Lower Octopus Lake at Deer Road (Site 2)

The waters of lower Octopus Lake, adjacent to Deer

TABLE 1

RIDING MOUNTAIN NATIONAL PARK - WATER QUALITY DATA

Upper Octopus Lake — Site 1

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | 19 | 20.5 | |
| pH | | 7.5 | 7.5 | 7.5 | -- |
| Conductivity | umho/cm | 283 | 300 | 309 | 297 |
| Dissolved Oxygen | mg/L | 9.7 | 3.0 | 2.6 | 5.1 |
| Total Alkalinity | mg/L (as $CaCO_3$) | 148 | 160 | 164 | 157 |
| Bicarbonate Alkalinity | mg/L | 180 | 195 | 200 | 192 |
| Carbonate Alkalinity | mg/L | 0.0 | 0.0 | 0.0 | 0.0 |
| Biochemical Oxygen Dem. | mg/L | <0.1 | 1.1 | <5.0 | 2.1 |
| Total Organic Carbon | mg/L | 19.0 | 27.0 | 29.0 | 25.0 |
| Total Inorganic Carbon | mg/L | 33.0 | 36.5 | 33.0 | 34.1 |
| Ammonia Nitrogen | mg/L | <0.02 | 0.02 | <0.02 | 0.02 |
| Organic Nitrogen | mg/L | 1.38 | 1.08 | 1.08 | 1.18 |
| Nitrate Nitrogen | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| Total Phosphorus | mg/L | 0.11 | 0.08 | 0.14 | 0.11 |
| Filterable Residue | mg/L | 200 | 190 | 200 | 197 |
| Non-Filterable Residue | mg/L | <5 | <5 | 8 | 6 |
| Total Coliform Bacteria | per 100 mL | 43 | 4600 | 1500 | 2000 |
| Fecal Coliform Bacteria | per 100 mL | 0 | 93 | 23 | 39 |

Road, had exceptionally heavy growths of aquatic plants and algae to the extent that extreme eutrophic conditions existed. The organic content ($BOD_5$ and TOC) of these waters was noticeably higher than for upper lake waters (Table 2).

There was a severe depletion of dissolved oxygen throughout the summer, which reflected the oxygen demand imposed by decaying vegetation and other organic materials present.

Nutrients values were significantly above those reported for upper Octopus Lake. This is indicative of the impact of anthropogenic activities in the immediate area. The presence of some fecal coliform bacteria in this area raises the possibility of sewage contamination (refer to section 4.2).

4.1.3 Lower Octopus Lake at Riding Academy (Site 3)

Sampling Site 3 is located in Octopus Lake near the point of outflow to Ominnik Marsh. Water from this area of Octopus Lake drains beneath Provincial Highway No. 10, through a culvert, to Ominnik Marsh. During the study period there was little outflow, so that the lake and marsh were virtually isolated from one another for an extended period.

TABLE 2

RIDING MOUNTAIN NATIONAL PARK - WATER QUALITY DATA

Lower Octopus Lake at Deer Road Site 2

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | 19 | 20.5 | |
| pH | | 7.6 | 7.5 | 7.4 | -- |
| Conductivity | umho/cm | 520 | 440 | 422 | 461 |
| Dissolved Oxygen | mg/L | 0.8 | 0.1 | 0.5 | 0.5 |
| Total Alkalinity | mg/L (as $CaCO_3$) | 274 | 216 | 212 | 234 |
| Bicarbonate Alkalinity | mg/L | 334 | 264 | 259 | 263 |
| Carbonate Alkalinity | mg/L | 0.0 | 0.0 | 0.0 | 0.0 |
| Biochemical Oxygen Dem. | mg/L | 1.6 | 7.7 | 12.0 | 7.1 |
| Total Organic Carbon | mg/L | 53.5 | 24.5 | 45.0 | 41.0 |
| Total Inorganic Carbon | mg/L | 66.5 | 56.5 | 40.0 | 54.3 |
| Ammonia Nitrogen | mg/L | <0.02 | 0.02 | 0.12 | 0.05 |
| Organic Nitrogen | mg/L | 1.38 | 1.58 | 1.88 | 1.61 |
| Nitrate Nitrogen | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| Total Phosphorus | mg/L | 0.11 | 0.29 | 0.5 | 0.30 |
| Filterable Residue | mg/L | 390 | 320 | 310 | 340 |
| Non-Filterable Residue | mg/L | <5 | 32 | 33 | 23 |
| Total Coliform Bacteria | per 100 mL | 43 | 210 | 43 | 99 |
| Fecal Coliform Bacteria | per 100 mL | 9 | 9 | 9 | 9 |

TABLE 3

RIDING MOUNTAIN NATIONAL PARK - WATER QUALITY DATA

Lower Octopus Lake at Riding Academy Site 3

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | 18 | 17.3 | |
| pH | | 7.5 | 7.4 | 7.5 | -- |
| Conductivity | umho/cm | 418 | 433 | 428 | 424 |
| Dissolved Oxygen | mg/L | 0.6 | 0.6 | 2.4 | 1.2 |
| Total Alkalinity | mg/L (as $CaCO_3$) | 216 | 218 | 212 | 215 |
| Bicarbonate Alkalinity | mg/L | 264 | 266 | 259 | 286 |
| Carbonate Alkalinity | mg/L | 0.0 | 0.0 | 0.0 | 0.0 |
| Biochemical Oxygen Dem. | mg/L | 2.9 | 4.8 | 5.5 | 4.4 |
| Total Organic Carbon | mg/L | 40 | 42 | 48 | 43 |
| Total Inorganic Carbon | mg/L | 49 | 57.5 | 40 | 48.8 |
| Ammonia Nitrogen | mg/L | 0.07 | 0.07 | 0.03 | 0.06 |
| Organic Nitrogen | mg/L | 1.83 | 1.83 | 1.87 | 1.84 |
| Nitrate Nitrogen | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| Total Phosphorus | mg/L | 0.28 | 0.38 | 0.4 | 0.35 |
| Filterable Residue | mg/L | 310 | 310 | 330 | 317 |
| Non-Filterable Residue | mg/L | 22 | 47 | 24 | 31 |
| Total Coliform Bacteria | per 100 mL | 21 | 39 | 750 | 270 |
| Fecal Coliform Bacteria | per 100 mL | 15 | 4 | 4 | 8 |

The area of Octopus Lake near the riding academy had a heavy growth of aquatic plants and algae, similar to the eutrophic condition observed for Site 2. The organic content of these waters was also similar to Site 2 as was the low concentration of dissolved oxygen which indicated a high oxygen demand.

The high concentrations of nutrients promoted plant and algal growth. The source of these nutrients was likely the runoff from adjacent land areas, particularly the riding academy.

4.1.4 Ominnik Marsh Inlet (Site 4)

During the sample collection period, there was little flow from Octopus Lake into Ominnik Marsh. Site 4 was not, therefore, observably affected by Octopus Lake waters during the sample collection period.

The values reported for conductivity, alkalinity, inorganic carbon, and filterable residues tended to be high in comparison to all other sampling locations in Octopus Lake, Ominnik Marsh, South Lake and Clear Lake. Also, these values were likely interrelated (Table 4). The water in this area was typically less than a foot in depth, and the noted constituents were likely concentrated due to the

TABLE 4

RIDING MOUNTAIN NATIONAL PARK - WATER QUALITY DATA

Ominnik Marsh Inlet Site 4

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | 16 | 18 | |
| pH | | 7.7 | 7.7 | 7.7 | -- |
| Conductivity | umho/cm | 832 | 897 | 861 | 863 |
| Dissolved Oxygen | mg/L | 8.7 | 4.7 | 4.5 | 6.0 |
| Total Alkalinity | mg/L (as $CaCO_3$) | 406 | 442 | 430 | 426 |
| Bicarbonate Alkalinity | mg/L | 495 | 539 | 525 | 520 |
| Carbonate Alkalinity | mg/L | 0.0 | 0.0 | 0.0 | 0.0 |
| Biochemical Oxygen Dem. | mg/L | 1.3 | 3.4 | <5.0 | 3.3 |
| Total Organic Carbon | mg/L | 18.5 | 22.5 | 29.0 | 23.3 |
| Total Inorganic Carbon | mg/L | 104 | 108 | 78 | 97 |
| Ammonia Nitrogen | mg/L | 0.05 | 0.03 | 0.02 | 0.03 |
| Organic Nitrogen | mg/L | 0.75 | 0.87 | 0.98 | 0.87 |
| Nitrate Nitrogen | mg/L | <0.01 | 0.2 | <0.01 | 0.07 |
| Total Phosphorus | mg/L | 0.04 | 0.14 | 0.18 | 0.12 |
| Filterable Residue | mg/L | 590 | 640 | 570 | 600 |
| Non-Filterable Residue | mg/L | 10 | <5 | 12 | 9 |
| Total Coliform Bacteria | per 100 mL | <1 | 200 | 460 | 220 |
| Fecal Coliform Bacteria | per 100 mL | <1 | 39 | 43 | 27 |

evaporation which would occur at this shallow and somewhat isolated sampling site during the warm, dry sample-collection period. There are no environmental or public health concerns with the reported values for the noted parameters.

During the summer there tended to be a build-up of organic materials ($BOD_5$ and TOC), presumably due to decaying vegetation, and a concomitant decline in dissolved oxygen. This did not appear to be a problem, but further oxygen depletions would be detrimental to aquatic organisms.

Nutrient values (nitrogen, phosphorus) were not excessive. This was consistent with the fact there was little algal growth in these waters. The nutrient values of the waters immediately upstream in Octopus Lake had generally higher nutrient values, and could promote further aquatic plant and algal growth if they entered the receiving waters at Site 4 in an undiluted fashion.

For the most part, all parameters were consistent during the summer, and no environmental concerns were identified at Site 4.

### 4.1.5 Ominnik Marsh - Adjacent to Wasagaming Lagoons (Site 5)

The area represented by this sampling location is adjacent to the Wasagaming lagoon system. An engineering study report prepared by James F. MacLaren Limited, "Engineering Study of Sewage Treatment and Disposal Requirements for Riding Mountain National Park, Manitoba" (4) concluded there was significant water lost from the Wasagaming lagoon system through exfiltration. On the basis of site observations it was concluded for the present study that some seepage would drain to that part of Ominnik Marsh represented by Site 5. The sampling point is also in the area which would receive discharges of effluent from the lagoon system, if discharges occurred. As the lagoon cells have not been discharged for several years, data obtained from Site 5 would indicate any impact resulting from seepage of lagoon system waters. No attempt was undertaken to determine if seepage was actually occurring.

The waters of Ominnik Marsh in the area of Site 5 appeared to undergo limited movement (flow). This area of the marsh had a dense growth of aquatic vegetation and was surrounded by trees and shrubs. A dense growth of algae accounted for the high values (Table 5) for non-filterable

TABLE 5

RIDING MOUNTAIN NATIONAL PARK - WATER QUALITY DATA

Ominnik Marsh - Adjacent to Wasagaming Lagoons — Site 5

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | -- | -- | -- |
| pH | | 7.8 | 7.3 | 7.4 | -- |
| Conductivity | umho/cm | 622 | 590 | 572 | 595 |
| Dissolved Oxygen | mg/L | 2.8 | 0.02 | 1.2 | 1.3 |
| Total Alkalinity | mg/L (as $CaCO_3$) | 298 | 280 | 270 | 283 |
| Bicarbonate Alkalinity | mg/L | 364 | 342 | 329 | 345 |
| Carbonate Alkalinity | mg/L | 0.0 | 0.0 | 0.0 | 0.0 |
| Biochemical Oxygen Dem. | mg/L | 2.7 | 4.6 | 16.0 | 7.8 |
| Total Organic Carbon | mg/L | 21.5 | 17.5 | 51.5 | 30.2 |
| Total Inorganic Carbon | mg/L | 68.5 | 67.0 | 32.5 | 56.0 |
| Ammonia Nitrogen | mg/L | 0.12 | 0.06 | 0.06 | 0.08 |
| Organic Nitrogen | mg/L | 0.88 | 0.94 | 1.24 | 1.02 |
| Nitrate Nitrogen | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| Total Phosphorus | mg/L | 0.36 | 0.7 | 0.7 | 0.6 |
| Filterable Residue | mg/L | 410 | 370 | 370 | 383 |
| Non-Filterable Residue | mg/L | 11 | 51 | 86 | 49 |
| Total Coliform Bacteria | per 100 mL | 15 | 1500 | 93 | 540 |
| Fecal Coliform Bacteria | per 100 mL | 0 | 43 | 23 | 22 |

residues (suspended solids).

The values for conductivity, alkalinity, filterable residues, and, to a lesser extent, inorganic carbon tended to be high, somewhat similar to Site 4 (Tables 4 and 5). Over the course of the sampling period, there was an increase in the organic material present as indicated by the $BOD_5$ and TOC concentrations (Table 5). Low dissolved oxygen levels indicated a high oxygen demand. This was likely caused by accumulated dead vegetation and perhaps organic materials contained in seepage from the lagoons.

The general level of nitrogen nutrients tended to be comparable with that at the other stations. The phosphorus values were significantly above the values for most other sampling sites in the Clear Lake drainage system. These phosphorus concentrations were explained in part by the inflow of nutrients from Octopus Lake and surface runoff. It was not established if some nutrients were entering this area of Ominnik Marsh as a result of seepage from the lagoon system.

The bacteriological quality of the water at Site 5 was comparable to that at other sampling points on the Clear Lake drainage system.

### 4.1.6 Ominnik Marsh Drainage Ditch Inlet (Site 6)

The northwest corner of Ominnik Marsh contained clear water, free of noticeable algal growth. The pH was slightly higher than upstream sampling sites and some alkalinity was present as carbonate alkalinity (Table 6). This was comparable to South Lake and Clear Lake.

The dissolved oxygen present in the outfall waters was high, indicating a low oxygen demand. A major difference noted between these waters and those discussed previously was the very low levels of phosphorus nutrients here. This accounted for the lack of aquatic plants and algae. The bacteriological quality of the water at the outlet of Ominnik Marsh was comparatively good. Further bacteriological sampling would be required to confirm the high fecal coliform value determined for August 17.

### 4.1.7 Ominnik Marsh Drainage Ditch Outfall (Site 7)

This sampling station was characterized by clear waters, relatively free of aquatic plants and algae. The distance between Site 6 and 7 is estimated to be one kilometre but the water quality data for both sites were closely comparable (Tables 6 and 7). It is suggested that some mixing with South Lake waters may have occurred at this

TABLE 6

RIDING MOUNTAIN NATIONAL PARK - WATER QUALITY DATA

Ominnik Marsh Drainage Ditch Inlet — Site 6

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | 26 | 24 | -- |
| pH | | 8.0 | 8.6 | 7.9 | -- |
| Conductivity | umho/cm | 587 | 388 | 504 | 493 |
| Dissolved Oxygen | mg/L | >14.0 | 12.2 | 13.0 | 13.1 |
| Total Alkalinity | mg/L (as $CaCO_3$) | 294 | 184 | 244 | 241 |
| Bicarbonate Alkalinity | mg/L | 359 | 210 | 298 | 289 |
| Carbonate Alkalinity | mg/L | 0.0 | 7.2 | 0.0 | 2.4 |
| Biochemical Oxygen Dem. | mg/L | 11.0 | 1.6 | <5.0 | 5.9 |
| Total Organic Carbon | mg/L | 32.5 | 23.5 | 27.0 | 27.7 |
| Total Inorganic Carbon | mg/L | 63.0 | 36.0 | 50.5 | 49.8 |
| Ammonia Nitrogen | mg/L | 0.02 | 0.02 | 0.02 | 0.02 |
| Organic Nitrogen | mg/L | 0.93 | 1.08 | 0.98 | 1.00 |
| Nitrate Nitrogen | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| Total Phosphorus | mg/L | 0.03 | 0.04 | 0.06 | 0.04 |
| Filterable Residue | mg/L | 430 | 290 | 330 | 350 |
| Non-Filterable Residue | mg/L | <5 | <5 | <5 | <5 |
| Total Coliform Bacteria | per 100 mL | 210 | 23 | 460 | 230 |
| Fecal Coliform Bacteria | per 100 mL | 39 | 4 | 460 | 170 |

TABLE 7

RIDING MOUNTAIN NATIONAL PARK - WATER QUALITY DATA

Ominnik Marsh Drainage Ditch Outfall — Site 7

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | 26 | 24 | -- |
| pH | | 7.8 | 8.7 | 8.3 | -- |
| Conductivity | umho/cm | 574 | 408 | 429 | 470 |
| Dissolved Oxygen | mg/L | -- | <14.0 | 12.8 | 13.4 |
| Total Alkalinity | mg/L (as $CaCO_3$) | 286 | 194 | 200 | 227 |
| Bicarbonate Alkalinity | mg/L | 349 | 222 | 244 | 272 |
| Carbonate Alkalinity | mg/L | 0.0 | 7.2 | 0.0 | 2.4 |
| Biochemical Oxygen Dem. | mg/L | 6.5 | 3.8 | <5.0 | 5.1 |
| Total Organic Carbon | mg/L | 28.0 | 31.0 | 22.0 | 27.0 |
| Total Inorganic Carbon | mg/L | 65.0 | 44.0 | 44.5 | 51.2 |
| Ammonia Nitrogen | mg/L | 0.02 | 0.03 | <0.02 | 0.02 |
| Organic Nitrogen | mg/L | 1.28 | 1.67 | 1.08 | 1.34 |
| Nitrate Nitrogen | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| Total Phosphorus | mg/L | 0.11 | 0.08 | 0.04 | 0.08 |
| Filterable Residue | mg/L | 430 | 310 | 280 | 340 |
| Non-Filterable Residue | mg/L | 21 | 28 | 11 | 20 |
| Total Coliform Bacteria | per 100 mL | 460 | 4 | 460 | 310 |
| Fecal Coliform Bacteria | per 100 mL | 460 | 0 | 75 | 180 |

sampling site. The non-filterable residues near the drainage ditch outfall were slightly higher than at Site 6. This was likely due to a heavier growth of algae responding to slightly higher nutrient (organic nitrogen and total phosphorus) concentrations at this outfall.

### 4.1.8 South Lake (Site 8)

South Lake had a heavy growth of aquatic plants along the shoreline, and a well-dispersed algal growth. The algal growth is reflected by the non-filterable residue values reported (Table 8).

The lower $BOD_5$ value indicated that there was little accumulation of degradable organic material. The total organic carbon had a tendency to be high, indicative of the accumulation of vegetative matter somewhat resistent to degradation. This was confirmed by the high concentrations of dissolved oxygen which indicated a low oxygen demand. The higher organic nitrogen reported was likely associated with these organics.

The reported values for organic nitrogen and phosphorus indicate a good supply of nutrient materials to support vegetative growth. It is likely that some of these nutrients are recycled within the lake. It is also likely

TABLE 8

RIDING MOUNTAIN NATIONAL PARK - WATER QUALITY DATA

South Lake — Site 8

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | 24 | 26 | -- |
| pH | | 8.8 | 8.8 | 8.8 | -- |
| Conductivity | umho/cm | 405 | 423 | 462 | 430 |
| Dissolved Oxygen | mg/L | 12.8 | 11.1 | 11.5 | 11.8 |
| Total Alkalinity | mg/L (as $CaCO_3$) | 198 | 190 | 220 | 203 |
| Bicarbonate Alkalinity | mg/L | 207 | 207 | 244 | 219 |
| Carbonate Alkalinity | mg/L | 16.8 | 12.0 | 12.0 | 13.6 |
| Biochemical Oxygen Dem. | mg/L | 1.7 | 2.1 | <5.0 | 2.9 |
| Total Organic Carbon | mg/L | 44.0 | 18.5 | 49.0 | 37.2 |
| Total Inorganic Carbon | mg/L | 39.0 | 42.5 | 46.0 | 42.5 |
| Ammonia Nitrogen | mg/L | 0.05 | 0.02 | <0.02 | 0.03 |
| Organic Nitrogen | mg/L | 2.45 | 1.48 | 2.98 | 2.30 |
| Nitrate Nitrogen | mg/L | <0.01 | 0.05 | <0.01 | 0.02 |
| Total Phosphorus | mg/L | 0.10 | 0.06 | 0.14 | 0.10 |
| Filterable Residue | mg/L | 380 | 300 | 370 | 350 |
| Non-Filterable Residue | mg/L | 31 | 16 | 14 | 20 |
| Total Coliform Bacteria | per 100 mL | 9 | 240 | 460 | 240 |
| Fecal Coliform Bacteria | per 100 mL | 4 | 93 | 43 | 47 |

that surface runoff is the principal source of nitrogen and phosphorus entering South Lake.

The pH values were consistently high for South Lake but such levels are considered normal for western Canadian surface waters (5). At these higher pH levels some of the alkalinity is in the form of carbonate alkalinity.

South Lake is considered a eutrophic lake because it is shallow, has a heavy plant growth and has a good supply of nutrients. The natural processes of eutrophication are likely being accelerated by anthropogenic sources of nutrients, particularly phosphorus.

### 4.1.9 Clear Lake (Site 9)

The data for Clear Lake were characteristically uniform for each parameter during the sample collection period (Table 9). The waters of Clear Lake were very clear and relatively free of plant and algal growth in the sampling area. Consistent with this there were relatively low concentrations of nitrogen and phosphorus nutrients to accelerate growth. The high nitrate value of July 26 was considered a sampling or analytical anomaly.

Samples were collected along the shoreline and the

TABLE 9

RIDING MOUNTAIN NATIONAL PARK - WATER QUALITY DATA

Clear Lake Site 9

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | 21 | 21 | -- |
| pH | | 8.6 | 8.5 | 8.5 | -- |
| Conductivity | umho/cm | 407 | 420 | 420 | 416 |
| Dissolved Oxygen | mg/L | 13.0 | 8.7 | 8.9 | 10.2 |
| Total Alkalinity | mg/L (as $CaCO_3$) | 182 | 182 | 180 | 181 |
| Bicarbonate Alkalinity | mg/L | 202 | 207 | 210 | 206 |
| Carbonate Alkalinity | mg/L | 9.6 | 7.2 | 4.8 | 7.2 |
| Biochemical Oxygen Dem. | mg/L | 1.3 | <1.0 | <5.0 | 2.4 |
| Total Organic Carbon | mg/L | 9.0 | 9.5 | 12.0 | 10.2 |
| Total Inorganic Carbon | mg/L | 40.0 | 42.0 | 36.0 | 39.3 |
| Ammonia Nitrogen | mg/L | <0.02 | 0.03 | <0.02 | 0.02 |
| Organic Nitrogen | mg/L | 0.58 | 0.37 | 0.38 | 0.44 |
| Nitrate Nitrogen | mg/L | <0.01 | 0.42 | <0.01 | 0.15 |
| Total Phosphorus | mg/L | 0.02 | 0.03 | 0.06 | 0.04 |
| Filterable Residue | mg/L | 320 | 270 | 250 | 280 |
| Non-Filterable Residue | mg/L | 15 | <5 | 11 | 10 |
| Total Coliform Bacteria | per 100 mL | 240 | 460 | 1500 | 730 |
| Fecal Coliform Bacteria | per 100 mL | 240 | 93 | 1500 | 610 |

slight turbulance created by wave action, which was considered minimal at the times of each sample collection, may have caused some increase in non-filterable residues.

The pH of Clear Lake and South Lake were more alkaline than upstream waters (pH range: 8.5 to 8.8). This range is considered normal for western Canadian surface waters (5). As a result of the higher pH some of the alkalinity was present as carbonate alkalinity, as was reported for South Lake.

There was a good supply of dissolved oxygen present. This fact and the low concentrations of organic matter ($BOD_5$ and TOC) were indicative of a low oxygen demand.

Clear Lake is much larger and deeper than the previously reported lake and marsh waters, and there is little evidence of eutrophication. Any drainage to Clear Lake of waters containing excessive nutrients could, however, ultimately affect its water quality.

The values reported for bacteriological quality were comparatively high. Further sampling would be required to confirm the bacteriological quality.

## 4.2 Impact of Run-off from Developments South of Wasagaming

Determination of the qualities and quantities of run-off waters entering Octopus Lake was beyond the scope of this study. The run-off comes from various sources including agricultural land, the Village of Onanole, developments in the Deer Road area, commercial establishments along the east side of Provincial Highway Number 10, the Elkhorn Ranch Resort and the riding academy. The study did not include an updated inventory of wastewater disposal practices, completed in 1976 by James F. MacLaren Limited (4), and other sources of run-off contamination, but the common means of wastewater disposal for homes, cottages and businesses surrounding lower Octopus Lake is predominantly septic tank and tile field systems; this is also the case for the Village of Onanole.

There was limited evidence of fecal coliform contamination in Octopus Lake which indicated there was little or no raw sewage entering these waters. It is likely, however, that seepage from the septic tank tile fields in this area can reach the lake, particularly if these systems are poorly designed or constructed, improperly maintained, or otherwise malfunction. It is also noted that development in the area surrounding Octopus Lake has cumulatively reduced the water retention capacity of the land as a result of the construction of roads and drainage ditches, and the

landscaping of property.

The data for sampling sites on Octopus Lake indicates there is an accumulation of nutrient materials and organic materials in the upper reaches of the lake. The eutrophic condition will presumably deteriorate further as developments outside Wasagaming proceed (for example: Mountain Estates and Grey Owl Estates). Any degradation of Octopus Lake will ultimately be reflected in the water quality of Ominnik Marsh.

## 4.3 The Wasagaming Lagoon System

Raw sewage is pumped from the main Wasagaming lift station to cell one of the three-celled lagoon system (Figure 3). Cell one discharges to cell two, and cell two discharges to cell three. These cells are interconnected by valved connections at approximately the two foot level and also by overflow culverts at the five foot level. Effluent can be discharged from cell three to Ominnik Marsh immediately north of the lagoon system.

The parameters selected for surface water quality measurement were also used to determine the quality of wastewater in the Wasagaming lagoon system, including that of raw sewage.

There is no metering of sewage flows to record hydraulic loading to the lagoons. The study conducted by James F. MacLaren Limited in 1976 (4) stated that the storage capacity of the lagoons is 21.4 million gallons, while in excess of 60 million gallons are pumped to the lagoons annually. It estimated that only 6.3 million gallons were actually discharged from the lagoon system annually, and that in excess of 50 million gallons were lost through exfiltration.

With respect to organic loading, the Province of Manitoba design criteria recommend a loading limit to the primary cell of 50 lb. $BOD_5$ per acre of lagoon surface area per day. MacLaren (4) stated that during the summer months the calculated organic loading was between 52 and 105 lbs. $BOD_5$/acre/day. This is offset, however, by the fact that cell two also functions as a primary cell. Furthermore, the heavy organic loading is restricted to a period of approximately two months during the summer.

### 4.3.1 Main Lift Station - Raw Sewage

The samples taken at the lift station represent the quality of wastewater entering cell one of the Wasagaming lagoon system. Raw sewage may be generally classified as "weak", "medium" or "strong" on the basis of several commonly used parameters (6). On the basis of data

available from the present study the raw sewage entering the Wasagaming lagoon system during the summer may be classified as being between "weak" and "medium". During other times of the year it is presumably very weak due to low organic loading, and also because sewer line infiltration is reported as the predominant source of water entering the sewer system (4).

The pH of raw sewage was alkaline (Table 10). There was a high value for suspended solids (non-filterable residue) reflecting the large amount of particulate materials carried in suspension. The dissolved solids (filterable residue) and conductivity values tended to be high, reflective of the dissolved materials present.

Several of the parameters, including alkalinity, $BOD_5$, ammonia nitrogen, phosphorus, filterable residues, and nonfilterable residues tended to have increasing values during the course of the summer sampling period. This indicated that heavier organic loading was taking place during July and August.

It was observed that during July and August there was a noticeable depletion of oxygen in the raw sewage. This was not unexpected and was not considered a problem. It may have been related to one or more factors. First the sewage

TABLE 10

RIDING MOUNTAIN NATIONAL PARK - WASTEWATER QUALITY DATA

Wasa amin Lift Station
Raw Sewage

| Para eter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | -- | -- | -- |
| pH | | 7.35 | 8.0 | 7.3 | -- |
| Conductivity | umho/cm | 605 | 886 | 808 | 766 |
| Dissolved Oxygen | mg/L | 10.1 | 5.5 | 1.0 | 5.5 |
| Total Alkalinity | mg/L (as $CaCO_3$) | 232 | 292 | 324 | 283 |
| Bicarbonate Alkalinity | mg/L | 283 | 356 | 395 | 345 |
| Carbonate Alkalinity | mg/L | 0.0 | 0.0 | 0.0 | 0.0 |
| Biochemical Oxygen Dem. | mg/L | 71 | 140 | 270 | 160 |
| Total Organic Carbon | mg/L | 74 | 207 | 91 | 124 |
| Total Inorganic Carbon | mg/L | 56 | 70.5 | 41 | 56 |
| Ammonia Nitrogen | mg/L | 10.8 | 36 | 36 | 28 |
| Organic Nitrogen | mg/L | -- | 29 | 13 | 21 |
| Nitrate Nitrogen | mg/L | 0.12 | 0.67 | <0.01 | 0.27 |
| Total Phosphorus | mg/L | 2.3 | 7.4 | 8.2 | 6.0 |
| Filterable Residue | mg/L | 280 | 510 | 550 | 447 |
| Non-Filterable Residue | mg/L | 130 | 110 | 410 | 220 |
| Total Coliform Bacteria | per 100 mL | 150,000+ | 110,000 | 150,000 | 137,000 |
| Fecal Coliform Bacteria | per 100 mL | 110,000 | 110,000 | 150,000+ | 123,000 |

during the mid-summer period is "stronger" than other times of the year and has a greater oxygen demand. Secondly, sewage temperatures during summer are warmer than at other times and this would increase the rate of oxygen utilization. Third, there may sometimes be temporary surcharging of the sewer lines due to high hydraulic flows, resulting in longer retention periods during which oxygen utilization continues.

Generally, there were no unusual observations made for the raw sewage quality. As expected, the sewage is of greater "strength" during the summer when the Wasagaming population peaks than during other times of the year.

### 4.3.2 Wasagaming Lagoon System - Cell Two

Samples were collected from cell two adjacent to the inlet from cell one. At this location, it is apparent that most suspended materials contained in the raw sewage have settled out and significant treatment has occurred. Towards the end of the summer, there were higher levels of suspended materials in cell two waters (Table 11). This, in part, reflected increased algal growth.

Dissolved oxygen data were not reported for the lagoon cells because the values determined in the field were

TABLE 11

RIDING MOUNTAIN NATIONAL PARK - WASTEWATER QUALITY DATA

Cell Two Wasagaming Lagoon System

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | -- | -- | -- |
| pH | | 9.2 | 9.8 | 8.6 | -- |
| Conductivity | umho/cm | 388 | 400 | 640 | 476 |
| Dissolved Oxygen | mg/L | -- | -- | -- | -- |
| Total Alkalinity | mg/L (as $CaCO_3$) | 166 | 168 | 258 | 197 |
| Bicarbonate Alkalinity | mg/L | 144 | 93 | 290 | 176 |
| Carbonate Alkalinity | mg/L | 28.8 | 55.2 | 12.0 | 32 |
| Biochemical Oxygen Dem. | mg/L | <5.0 | 4.3 | 31.0 | 13.4 |
| Total Organic Carbon | mg/L | 15.5 | 23.5 | 22.0 | 20.3 |
| Total Inorganic Carbon | mg/L | 26.5 | 57.5 | 96.0 | 60.0 |
| Ammonia Nitrogen | mg/L | 0.21 | 2.1 | 14.0 | 5.4 |
| Organic Nitrogen | mg/L | 1.39 | 2.1 | 10.0 | 4.5 |
| Nitrate Nitrogen | mg/L | 0.11 | 0.33 | 0.13 | 0.19 |
| Total Phosphorus | mg/L | 0.4 | 0.8 | 4.4 | 1.9 |
| Filterable Residue | mg/L | 300 | 300 | 420 | 340 |
| Non-Filterable Residue | mg/L | <5 | 5 | 44 | 20 |
| Total Coliform Bacteria | per 100 mL | 93 | 1,500 | 40,000 | 13,800 |
| Fecal Coliform Bacteria | per 100 mL | 93 | 1,500 | 11,000 | 4,200 |

unusually high and no explanation was determined. It appeared that there was a good oxygen supply in the lagoon cells at all times and this was not a limiting factor to treatment.

The pH values of 9.2, 9.8 and 8.6 in cell two demonstrated significant increases above those reported for raw sewage. The high pH values likely occurred because of the utilization of dissolved carbon dioxide (an acidic gas) by aquatic plants and algae. The activity of the algae likely contributed to high dissolved oxygen levels previously noted. As a result of the high pH conditions some alkalinity was present as carbonate alkalinity, but this does not represent a concern.

Although there are considerable amounts of organic materials and nutrients in the lagoon cells, there did not appear to be any problem with excessive algal growth.

Alkalinity and inorganic carbon tended to be higher on July 26 and August 17 than on June 24, and this is thought to reflect the accumulation of products of organic degradation.

The $BOD_5$ and TOC were higher during July and August, as compared to June, which reflects heavier organic loading in

the summer months. There was a significant reduction in the organic material between the lift station and cell two. This is largely the result of the settling, in cell one, of suspended materials which contain organics. This would also account for the significant reduction in nitrogen and phosphorus nutrient levels in cell two.

In comparison to the high concentrations reported for raw sewage, the ammonia values are greatly reduced in cells one and two as a result of oxidation to nitrates. This is indicative of effective treatment and adequate oxygen availability. There does not appear to be a corresponding accumulation of nitrates, because nitrates are presumably utilized by organisms in the lagoon system.

Towards the end of the summer (August 17) there was a noticeable increase in the ammonia and organic nitrogen values for cell two. This was indicative of the accumulation of these materials as a result of heavy organic loading.

The levels of total phosphorus in cell two were consistently much less than for raw sewage. This is explained by the fact that much of this phosphorus is settled out with the suspended solids in cells one and two. It is expected that the lagoon sediments contain a great

deal of phosphorus.

### 4.3.3 Wasagaming Lagoon System - Cell Three

Wastewater at this cell three sampling location, near the inlet from cell two, is considered to be representative of wastewaters which have been treated in cells one and two. Wastewater at this point would undergo further "treatment" before reaching the lagoon discharge point at the opposite end of cell three.

As was reported for cell two, the cell three pH values were high: 10.6, 9.9 and 9.4 (Table 12). This was considered to be due to the utilization of carbon dioxide by algae and aquatic plants during their photosynthetic activities. This was consistent with the indications that dissolved oxygen levels tended to be high. The high pH levels also resulted in greater amounts of alkalinity being present as carbonate alkalinity.

During the June and July sampling times, the wastewater quality at the cell three sampling location met federal effluent quality requirements for organic content ($BOD_5$), suspended solids (non-filterable residue), phosphorus, and microbiological quality (7). At the time of the August 17 sampling there were significant increases in $BOD_5$, suspended

TABLE 12

RIDING MOUNTAIN NATIONAL PARK - WASTEWATER QUALITY DATA

Cell Three Wasagaming Lagoon System

| Parameter | | Sampling Dates (1982) | | | Mean Value |
|---|---|---|---|---|---|
| | | June 24 | July 26 | Aug. 17 | |
| Temperature | $C^{o}$ | -- | -- | -- | -- |
| pH | | 10.6 | 9.9 | 9.4 | -- |
| Conductivity | umho/cm | 370 | 399 | 467 | 412 |
| Dissolved Oxygen | mg/L | -- | -- | -- | -- |
| Total Alkalinity | mg/L (as $CaCO_3$) | 160 | 168 | 258 | 197 |
| Bicarbonate Alkalinity | mg/L | 39.0 | 87.8 | 149 | 92 |
| Carbonate Alkalinity | mg/L | 76.8 | 57.6 | 43.2 | 59.2 |
| Biochemical Oxygen Dem. | mg/L | <5.0 | 3.7 | 57 | 21.9 |
| Total Organic Carbon | mg/L | 17.0 | 20.0 | 56.5 | 31.2 |
| Total Inorganic Carbon | mg/L | 20.0 | 25.0 | 50.5 | 31.8 |
| Ammonia Nitrogen | mg/L | 0.04 | 0.73 | 0.25 | 0.34 |
| Organic Nitrogen | mg/L | 1.16 | 1.57 | 10.75 | 4.5 |
| Nitrate Nitrogen | mg/L | 0.02 | 0.55 | 0.5 | 0.36 |
| Total Phosphorus | mg/L | 0.42 | 0.6 | 2.9 | 1.3 |
| Filterable Residue | mg/L | 260 | 280 | 350 | 297 |
| Non-Filterable Residue | mg/L | 11 | <5 | 54 | 23 |
| Total Coliform Bacteria | per 100 mL | 0 | 23 | 23 | 15 |
| Fecal Coliform Bacteria | per 100 mL | 0 | 4 | 9 | 4 |

solids, and total phosphorus beyond the recommended limits established in the guidelines (7). Bacteriological quality remained within the limits.

The August 17 data indicate there was an accumulation of materials in cell three during the summer which presumably was the result of heavy sewage flows. This was reflected by higher values for $BOD_5$, total organic carbon, alkalinity, phosphorus, nitrogen, conductivity, dissolved solids (filterable residue) and suspended solids. The higher suspended solids value could partly reflect an increase in algal growth.

## 4.4 Wasagaming Lagoon System Treatment Performance

Lagoon system performance is ultimately determined by the quality of the effluent to be discharged. Effluent quality limits have been established by the federal government (7). The primary criteria to determine performance are $BOD_5$, suspended solids, total phosphorus, fecal coliform bacteria and pH.

### 4.4.1 Treatment Performance During the Summer Sampling Period

The recommended limit for $BOD_5$ in effluent discharges is 20 mg/L and contents of cells two and three were well

within this limit for June 24 and July 26, but not for August 17. The mean $BOD_5$ reduction between the lift station (raw sewage) and cell three sampling location was 86 percent, which reflects significant organic removal and good treatment. While there was continued good phosphorus removal within the lagoon system during the summer there were also high concentrations entering in the raw sewage. By the August 17 sampling date, the total phosphorus levels were well above the federal effluent quality guideline limits in cells two and three.

The bacteriological quality, both total coliform bacteria and fecal coliform bacteria, of cells two and three indicates that the lagoon system is providing effective treatment with reduction of these bacteriological groups and presumably pathogens. During the three sampling periods, bacteriological levels in cell three were well within the recommended effluent quality limits for federal establishments (7) of 400 fecal coliforms per 100 ml.

### 4.4.2 System Recovery Following Summer Loading

No samples were collected following the summer to determine the conditions in the lagoon wastewater treatment system after heavy summer loadings. It is presumed, however, that a recovery would take place after August when

the number of park visitors sharply declined, and businesses and park facilities closed.

James F. MacLaren Limited (1) reported some lagoon system water quality data for October 18, 1976 (Table 13). Assuming that there was typical summer loading during 1976, it appears that by October 18 the wastewater in cells two and three was suitable for discharging with respect to $BOD_5$, suspended solids, fecal coliform bacteria and pH. The total phosphorus concentration in cells two and three approached the permissable discharge levels prescribed in the federal effluent guidelines (7). If the lagoon system data of August 1984 also approximated the conditions of August, 1976, then one could conclude that by approximately mid-October, there is a recovery from the heavy summer loading. There is a concern, however, that some of this "recovery" could result from the diluting effects of sewer line infiltration (see sections 4.5).

## 4.5 Operation of the Wasagaming Lagoon System

Before and during the sample collection period all raw sewage was pumped to cell one of the Wasagaming lagoon system. From there it flowed to cell two and then to cell three. The cells are also connected with overflow culverts and, because of high water levels in the system there was some short-

TABLE 13

RIDING MOUNTAIN NATIONAL PARK - WASTEWATER QUALITY DATA

Wasagaming Lagoon System
October 18, 1976

Data Reported by James F. MacLaren Limited (1)

| Parameter | | Lagoon Cell | | |
|---|---|---|---|---|
| | | Cell One | Cell Two | Cell Three |
| pH | | 9.4 | 7.85 | 8.25 |
| Biochemical Oxygen Demand | mg/L | 16.0 | 4.1 | 4.1 |
| Chemical Oxygen Demand | mg/L | 87.1 | 41.7 | 61.2 |
| Total Kjeldahl Nitogen | mg/L | 10.4 | 7.54 | 5.06 |
| Nitrate Nitrogen | mg/L | 0.232 | 0.238 | 0.22 |
| Total Phosphorus | mg/L | 2.16 | 1.77 | 1.22 |
| Filterable Residue | mg/L | 370 | 438 | 426 |
| Non-Filterable Residue | mg/L | 77.5 | 13.3 | 3.5 |
| Total Coliform Bacteria per 100 mL | | 1400 | 60 | 12 |
| Fecal Coliform Bacteria per 100 mL | | $16^{+}$ | 4 | <4 |

circuiting through the overflow from cell one to cell three.

For several years, Parks Canada maintenance staff have not discharged effluent from the Wasagaming lagoon system. Although the MacLaren studies have stated that a large amount of wastewater is being lost from the lagoons through exfiltration more specific evidence of this is necessary before recommending remedial action (see section 4.6).

For most lagoon systems it is considered preferable to discharge effluent in the fall because this permits retention of as much water as possible over the summer when treatment activity is maximized. The Wasagaming system is much different than most other domestic wastewater systems in that its organic loading is highly seasonal and there is very limited organic material entering the system in the fall, winter and spring. To maximize wastewater treatment effectiveness resulting from heavy summer use it is considered best to retain it over the fall, winter and early spring if possible.

During spring the lagoon waters, especially those in cells two and three, are of good quality and a discharge of some water from cell three would result in minimal impact to Ominnik Marsh. It is also anticipated that spring flows through Ominnik Marsh should be higher than at other times and

this would enhance flushing of lagoon effluents from the marsh. Lowering the water levels in the lagoon cells would presumably reduce the extent of any exfiltration.

## 4.6 Sewer Line Infiltration and Water Line Bleeding

James F. MacLaren Limited (4) calculated the annual flows to the Wasagaming lagoon system to be approximately 60 MIG. Sanitary sewage constituted only one-third of this flow. The remainder resulted from groundwater infiltration (one-third), and from bleeder line flows (one-third) necessary to prevent water lines freezing during the winter. MacLaren (4) made recommendations to reduce the requirement for bleeder flows and also to stop these flows entering the sanitary sewage system. Recommendations were made to reduce the amount of infiltration occurring by examining sewer lines to locate zones of high infiltration and then relining or reconstructing those sections. Reduction of excessive hydraulic loading to the Wasagaming lagoon system represents a reasonable and cost-effective way to increase the treatment performance, although this may not be reflected in better effluent quality. Under the present circumstances, some of the treatment indicated is essentially due to dilution.

## 4.7 Exfiltration from the Wasagaming Lagoon System

The 1976 study by James F. MacLaren Limited (4) reported the designed hydraulic capacity of the Wasagaming lagoon system to be 21.4 MIG. It is likely that sludge has accumulated since the lagoon cells were constructed which would effectivey reduce this capacity. James F. MacLaren calculated the annual hydraulic loading to the lagoon system to be approximately 60 MIG, which is much beyond the hydraulic capacity. Because there was no effluent being discharged from the system, it was concluded that as much as 50 MIG were being lost annually through exfiltration. There was no attempt in the present study to determine the amount of exfiltration occurring.

Groundwater in the area of the Wasagaming lagoon cells tends to flow westward towards South Lake (1). While this may be correct as a general condition, there is no doubt that exfiltration from the lagoon cells would enter Ominnik Marsh because the northern boundary of cells one and three is adjacent to the marsh. Also, there is a water head of several feet between the lagoon cells and the marsh.

James F. MacLaren Limited (1) stated there was no serious groundwater contamination indicated on the basis of some limited sampling from several bore holes dug at sites near the

Wasagaming lagoon cells. It was recommended that sampling should be continued for a year, but there was no follow-up. It is unlikely that any groundwater contamination resulting from exfiltration is measurably affecting South Lake or wells in the area.

While it is desirable to reduce exfiltration from the lagoon cells, James F. MacLaren Limited (1,4) did not recommend the installation of a synthetic liner, or the expansion of the present system to accommodate the annual flows. It is possible, however, to markedly reduce hydraulic loading to the lagoon system as discussed in section 4.5.

The high hydraulic flows to the Wasagaming lagoon system result in the cells usually being full. Since no discharging from the system has been conducted for several years, and no overflowing has occurred, it is reasonable to concur with James F. MacLaren Limited (1,4) that exfiltration is significant. The presence of high water levels in the lagoon cells likely exacerbates exfiltration. These high water levels could presumably be reduced by discharging during late spring (May) when the lagoon system contains well-treated wastewater, reducing or eliminating bleeder flows, and reducing sewer line infiltration. Minimizing exfiltration is especially important during summer when heavy organic loading occurs.

## 5.0 Conclusions

### 5.1 Octopus Lake

The waters of upper Octopus Lake tended to be eutrophic but contained only limited concentrations of nutrient materials. The waters of the lower reaches of Octopus Lake, however, were highly eutrophic; further increases in organic materials and nutrients will exacerbate this condition. The source of high nutrient concentrations in Octopus Lake is likely runoff from agricultural land, and adjacent cottage and commercial developments, including a horse stabling facility.

### 5.2 Ominnik Marsh

While Ominnik Marsh exhibited eutrophic conditions with respect to the growth of aquatic plants the water quality in the larger central marsh area was generally good, and exhibited relatively low concentrations of organic material and nutrients. The relatively high phosphorus values reported for the area of Ominnik Marsh adjacent to the Wasagaming lagoon system indicates some seepage from the lagoons is entering the marsh. The likely cause of peculiar odours emanating from Ominnik Marsh from time to time is the development of anaerobic conditions in the waters of the marsh adjacent to the Wasagaming lagoon system. Any significant

inflows of water from Octopus Lake to Ominnik Marsh could contain concentrations of nutrients that would negatively affect the marsh by promoting eutrophic conditions.

## 5.3 South Lake

Water draining from Ominnik Marsh to South Lake through the connecting drainage ditch does not undergo significant changes in quality between the marsh and the lake. These waters entering South Lake, however, do not represent a source of water quality degradation to South Lake. South Lake is an eutrophic lake and the principal source of nutrients entering the lake is likely runoff from adjacent agricultural land.

## 5.4 Clear Lake

The water quality of Clear Lake is good, with very low concentrations of nutrients and organic materials, and no indication of eutrophic conditions.

## 5.5 The Wasagaming Lagoon System

The organic and nutrient loadings to the Wasagaming lagoon system increase significantly during the summer concurrent with peak population levels at Riding Mountain National Park. The system provided effective treatment of raw

sewage throughout the study period as indicated by significant reductions in organic materials, dissolved and suspended materials, nitrogen and phosphorus nutrients, and total coliform and fecal coliform organisms. During the latter part of the summer, there was an accumulation in the Wasagaming lagoon system of organic materials, dissolved and suspended materials, nitrogen and phosphorus nutrients, together with a tendency for increases in total coliform and fecal coliform organisms, to the extent that, by August 17, effluent quality did not meet all federal guideline limits for discharging (7). Following the accumulation of organic and other materials during the summer there is evidence that the lagoon system recovers by mid-October to the extent that cell three waters will meet federal effluent quality guideline limits (7) for most applicable parameters. The Wasagaming lagoon system provides effective wastewater treatment and it is predicted that as long as federal guideline effluent discharge limits are met, there will be minimal, if any, impact on Ominnik Marsh as a result of discharges from cells two and three during the late spring.

## 5.6 Water Line Bleeding; Sewer Line Infiltration; Lagoon Exfiltration

The water entering the Wasagaming lagoon system as a result of water line bleeding during the winter and sewer line infiltration, significantly dilutes the wastewater and

exacerbates exfiltration. This excessive hydraulic loading could be significantly reduced by implementing the measures recommended by James F. MacLaren Limited (4) to curtail these flows. The single means used to mitigate exfiltration is to install a new liner of impervious soil or synthetic material, which involves high costs. There has been insufficient investigation to determine the extent of exfiltration from the Wasagaming lagoon system and any impact this may have on groundwater.

## 6.0 Recommendations

1. Future commercial and residential development in the Octopus Lake and Ominnik Marsh drainage area should be planned to limit and contain drainage which would otherwise enter these waters. Park and provincial planning authorities should consider the environmental problems which could be created by developments in this drainage area in determining allowable wastewater treatment practices for all commercial and residential developments.

2. Regular discharging of the Wasagaming lagoon system should be undertaken annually during late spring.

3. Before discharging from the lagoon system, samples of the wastewater to be discharged should be collected and analysed to ensure that the effluent meets federal effluent quality guideline limits (7).

4. Wastewater should be prevented from flowing through the overflow culvert from cell one to cell three. This can be achieved by operating at a maximum water level below the level of the overflow culverts, or the overflow culvert between cells one and three should be raised, valved or blocked to prevent short-circuiting of

wastewater flows.

5. The recommendations of James F. MacLaren Limited (4) to reduce or stop winter bleeding of water lines and sewer line infiltration should be implemented.

## 7.0 References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